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<u>L9</u>	L7 and ammonium	36	<u>L9</u>
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<u>L7</u>	L6 and magnesium	45	<u>L7</u>
<u>L6</u>	phosphorous and waste and ion exchange same membrane	84	<u>L6</u>
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L12: Entry 1 of 5

File: USPT

May 11, 2004

DOCUMENT-IDENTIFIER: US 6733662 B2

TITLE: Methods and apparatus for biological treatment of waste waters

Brief Summary Text (12):

Current wastewater treatment systems which attempt to provide tertiary treatment include Upflow Sludge Bed Filter (USBF), Sequencing Batch Reactor (SBR) and Membrane Separation Activated Sludge (MSAS) systems. The Sequencing Batch Reactor (SBR) process is a modification of the conventional activated sludge process. U.S. Pat. No. 5,503,748 discloses a long vertical shaft aerator applied to the SBR technology. The SBR process employs a number of discrete steps, typically comprising sequential fill, reaction, settlement and decantation of wastewater with biomass in an enclosed reactor. In the initial step of this process, wastewater is transferred into a reactor containing biomass, and combined to form a mixed liquor. In the reaction step of the treatment process the microorganisms of the biomass utilize and metabolize and/or take up the nitrogen, phosphorous and/or organic sources in the wastewater. These latter reactions may be performed under anaerobic conditions, anoxic conditions, aerobic conditions, or a combination thereof to manipulate organism growth, population dynamics and contaminant processing. The length of this stage will be dependent on the waste's characteristic, concentration of the biomass, and other factors. Following the reaction cycle, the biomass in the mixed liquor is allowed to settle out. A sludge blanket settles on the bottom of the reactor leaving a treated effluent supernatant. The treated and clarified wastewater (i.e. effluent) is subsequently decanted and discharged. The reactor vessel is then refilled and the treatment process cycle reinitiated. Thus, the sequencing batch reactor's process is based on discrete operation in time, whereas other wastewater treatment processes are based on distinct operations in space, e.g., by performance of different reactions in separate vessels.

Drawing Description Text (6):

FIG. 5 is a diagrammatic vertical section through one embodiment of a bioreactor according to the invention for use in waste water treatment. This embodiment features a pressurized head tank, an off gas collector means, said off gas driving an air lift influent pump required to overcome said head tank pressure, a membrane filtration cartridge operating under pressure to separate biomass from liquid and a clean water ultraviolet (UV) disinfecting chamber also serving as back wash storage for membrane backwashing.

Detailed Description Text (24):

At start up of the bioreactor 10, compressed air or other oxygen-containing gas or, alternatively, a liquid/gas solution or suspension, is delivered to a lower segment of the reactor to serve as an oxygenation source for aerobic waste processing in the bioreactor. Typically, compressed air is delivered to a sparger or air distribution header 60 anchored near the bottom of the riser channel 14 below the lower port of the downcomer channel 12 that serves to deliver the process air in a substantially dispersed array. Typically, the distribution header is flat topped or cone shaped with an optional, serrated skirt fixed to the perimeter underside. The header serves to disperse the process air in a substantially uniform, circular array of air bubbles that emerge as a rising curtain of bubbles from around the periphery of the header--below the lower port 20 of the downcomer channel and surrounding the mix zone 18. The mix zone is thus generally defined in one

embodiment of the invention as the lower portion of the riser channel below and surrounding the lower port of the downcomer channel and above and surrounding the air distribution header. The flow from the downcomer channel impinges on an upper surface 61 of the distribution header and is partially deflected upward. At the same time, bubbles released from the periphery of the header mix with the flow from the downcomer channel and contribute to turbulent mixing of this material, which thereby becomes less dense as a fluid-bubble mixture than the fluid in the downcomer channel. Accordingly, the resultant fluid-bubble mixture rises within the riser channel 14 to establish circulation in this portion of the bioreactor having the general circulatory pattern indicated by the arrows in FIG. 1.

Detailed Description Text (43):

Alternate embodiments of the bioreactor 10 illustrated in FIG. 4 feature moving bed media 130 circulating in zone 2 and, additionally or alternatively, fixed media 132 suspended in the head tank 15 of zone 2. Another embodiment, as illustrated in FIG. 5, incorporates a pressurized head tank 135, and an optional off gas collector 136 (see, e.g., U.S. Pat. No. 4,272,379 to Pollock, incorporated herein by reference), for example with off gas driving an air lift influent pump 137 required to overcome the head tank pressure, as well as an optional membrane filtration cartridge 138 (see, e.g., George Heiner et al, "Membrane Bioreactors" Pollution Engineering December 1999, incorporated herein by reference) operating under pressure to separate biomass from liquid and a clean water, ultraviolet (UV) disinfecting chamber 139 also serving as back wash storage for membrane backwashing. Still other embodiments, as shown in FIG. 6, feature an integrated clarifier 120' fluidly connected to an aerated polishing biofilter 133 and an ultra violet light disinfection chamber 134 and filter back wash tank.

Detailed Description Text (53):

Once the desired fraction of bubbles have been thus diverted into the zone 2 upflow channel 82, the voidage in this channel can be easily corrected by changing the amount of zone 2 recycle flow through adjustment of the zone 2 recycle flow regulator 112. The circulatory loop (following arrows between zone 2 upflow channel 82, across zone 2 degas plate 150, through zone 2 recycle regulator 112, down zone 2 recycle channel 110, and through zone 2 shielded recirculation port 152), together with a surface basin or zone 2 head tank 15 at the top, comprise zone 2 and represent the polishing process and optional nitrification features of the bioreactor which are driven by waste gas from zone 1. The configuration of the diverter which segregates flow into the superior upflow channels prevents liquor transfer from zone 2 into zone 1, since both liquid and air flow in the zone 2 upflow channel 82 is unidirectionally upward. In this regard, as noted above, zone 2 circulation characteristics are ideal for the application of fixed media 132 (FIG. 4) and, alternatively or cooperatively, membrane separation components (FIG. 5). Moving bed media 130 (FIG. 4) can also be used, since zone 2 circulates completely separately from zone 1, to enhance nitrification within alternative process modes of the reactor.

Detailed Description Text (78):

The selection of operating temperatures is very important in long, vertical thermophilic aerobic digesters because ammonium bicarbonate decomposes at about 60.degree. C. Ammonium bicarbonate is very important in the efficiency of the solids liquid separation (dewatering) step of the process. For instance, when operating a deep vertical thermophilic aerobic digester at 55.degree. C. to 58.degree. C., the digested sludge samples were very granular before drying the sample but not after drying at about 104.degree. C. On one occasion when the head tank was opened without cooling the reactor (for emergency repair of a float switch), the inside surface, particularly the uninsulated access cover, was coated with tiny white angular crystals much like white sugar or salt. These crystals subsequently disappeared and were not found again at the higher operating temperatures. Another observation that is common, is that when a batch of product is transferred into the soak zone at about 58.degree. C. (where there is negligible

biological activity), the temperature increases and holds constant for about 2 hours, then cools at the cool-down rate of the reactor when operating on hot water. The heat of crystallization of 10,000 mg/L of ammonium bicarbonate would account for the apparent heat generated in the soak zone. Empirically, these observations would suggest the formation of ammonium bicarbonate crystals below 60.degree. C. This is contradicted by the fact that ammonium bicarbonate is very soluble in water, but less so in the presence of high levels of other dissolved solids, and perhaps the surface chemistry of the microbiology facilitate the crystallization process. For instance, Struvite (magnesium ammonium phosphate) is readily formed in anerobic digesters of plants using biological phosphorus removal but not in plants using chemical phosphorus removal. Controlling the reactor temperature to below 60.degree. C. may allow ammonium bicarbonate crystals to form which would easily float separate with the sludge.

Detailed Description Text (102):

Membrane separation, although expensive, eliminates many of the operational problems of clarifiers in BNR plants. In the present invention membrane separation allows much higher MLSS and a smaller reactor. Membrane separation provides a better quality recycle water than the present standards require.

Detailed Description Text (103):

The upper right of FIG. 13 is the final chemical treatment of tertiary water to meet recycle quality standards. By current law, chemical flocculation, filtration and residual chlorine must be used. Unit M is a flocculating tank with mechanical mixer. Unit N is a rotating cloth disk filter. Unit P is a ultra violet disinfection channel and combined back wash tank. Unit O is a chlornination step where just enough chlorine is added to maintain a residule in the pipe line. Unit Q is a back wash pump which can be used to backwash the cloth filter or the membranes if required.

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L12: Entry 2 of 5

File: USPT

Feb 17, 2004

DOCUMENT-IDENTIFIER: US 6692642 B2

TITLE: Organic slurry treatment process

Abstract Text (1):

A process is provided for full treatment of animal manure and other organic slurries containing suspended solids, and dissolved organic matter, nitrogen, and phosphorus, without the need for anaerobic digestion or anaerobic stabilization lagoons. The process includes: centrifugal decanting, flocculation, dissolved air flotation thickening, centrate heating, acidification in fluidized bed reactor, biological removal of phosphorus, nitrogen and dissolved organic matter in microfiltration membrane bioreactor and disinfection with ultraviolet radiation. The process separates liquids from solids, converts solids into organo-mineral fertilizer pellets, and treats the liquid to dischargeable standards. Land application for effluent disposal is not required because the treatment removes all nutrients.

Brief Summary Text (9):

Accordingly, the present invention provides a process for treating an organic slurry comprising a mixture of solids suspended in a liquid, colloidal solids and dissolved pollutants such as nitrogen, phosphorus and organic matter, the process comprising: flocculating a slurry stream with anionic polymer or a coagulant, or both, to aggregate suspended and colloidal solids into a floc, to form a flocculated stream; removing flocs from the flocculated stream to form a deflocced stream; feeding the deflocced stream into a high biomass concentration suspended growth system to remove biologically at least a portion of the organic and inorganic nitrogen, and remove by biological luxury uptake at least a portion of the phosphorus, wherein the system comprises: a multi-stage sequence of an anaerobic zone, an anoxic zone, and an aerobic zone, each zone separated with baffles, operating in a biomass recycle pattern from the anoxic zone to the anaerobic zone, and from the aerobic zone to the anoxic zone, with biomass wastage from the aerobic zone; and microfiltration membranes to filter liquid out of the aerobic zone to form a low-turbidity permeate.

Brief Summary Text (19):

Acidified effluent from the AFBR, or the deflocced stream if readily biodegradable, and preferably also stripped condensate from the ammonium recovery process, are fed to the BNR, which is designed to biologically remove phosphorus and nitrogen, while consuming organic matter simplified to VFA in the AFBR as carbon source for these processes. Carbon requirements for denitrification and phosphorus removal are supplied by VFA available in acidified effluent supplemented by volatile organic matter present in the stripped condensate. BNR treatment rate and efficiency in this process are maximized using submerged microfiltration membranes along with a multi-stage suspended growth biological nutrient removal system. The synergies brought about by this membrane bioreactor/biological nutrient removal (MBR/BNR) combination enable the system to remove efficiently very high dissolved organic matter, nitrogen and phosphorus loads. Additionally, this combination provides high solids retention time, which introduces process stability, reduces biomass production and enables slow-growing organisms, such as nitrifiers, to establish a healthy population. Heavy metals present in the waste stream are also significantly reduced in this system.

Brief Summary Text (20):

The MBR/BNR system comprises a multi-stage Modified Bardenpho configuration with a sequence of at least anaerobic, anoxic and aerobic suspended growth zones, and preferably consists of a five-stage Modified Bardenpho configuration with a sequence of anaerobic, anoxic, aerobic, anoxic and aerobic suspended growth zones. The pattern of biomass recirculation between zones is typical of a conventional University of Cape Town (UCT) process flow. Effective separation of liquid and biomass achieved with microfiltration membranes submerged in the final aerobic zone allows the system to operate with extremely high biomass concentrations and long solids retention times. The liquid passing through the membrane or permeate has no suspended solids, extremely low phosphorus, nitrogen and dissolved organic matter. Microfiltration removes a significant portion of pathogen indicator organisms and produces an effluent with low turbidity. If necessary, the permeate is disinfected using low dosages of ultraviolet radiation prior to reuse as plant service water and discharge.

Brief Summary Text (21):

The combination of the five-stage suspended growth sequence, the biomass recycle pattern, and the microfiltration membranes producing permeate from aerobic zone 2 creates a synergistic effect that enables biological removal of high loads of nitrogen, phosphorus and dissolved organic matter contained in any liquid waste with high concentrations thereof.

Detailed Description Text (29):

Approximately 350 kg/day of alum J and 70 kg/d of anionic polymer I are added to reach a concentration of approximately 180 mg/L and 36 mg/L respectively. With alum and polymer, the DAFT units L remove over 79 percent of the remaining phosphorus. A small fraction of the removal is the result of phosphate reacting with calcium carbonate, magnesium and ammonia present in the centrate and precipitating as hydroxyapatite and struvite.

Detailed Description Text (41):

Microfiltration Membrane Bioreactor (MBR) Biological Nutrient Removal (BNR) System

Detailed Description Text (42):

Acidification FBR effluent 8 and air stripped condensate 16-1 combine into stream 9 before entering the Microfiltration Membrane Bioreactor (MBR) Biological Nutrient Removal (BNR) system. The MBR/BNR is a suspended growth process operating with 20 g/L mixed liquor suspended solids (MLSS) concentration. It combines biological nitrification/de-nitrification, and enhanced biological phosphorus removal (EBPR) in a single 6,500-m³ concrete tank containing two parallel treatment trains. Side water depth in the tank is 6 meters.

Detailed Description Text (43):

Each parallel train has five compartments, or zones, separated by baffles. Additional baffles are placed within each zone to approximate plug-flow conditions. The treatment sequence and sludge recirculation pattern corresponds to a Modified Bardenpho/University of Cape Town (UCT) multi-stage sludge process, enhanced with the use of submerged microfiltration membranes for biomass/liquid separation.

Detailed Description Text (45):

In MBR, biomass separation from treated effluent is done by physical retention of bacterial biomass by microfiltration membranes submerged in the reactor. Consequently, the need for flocculation is eliminated and a highly active and specific population can be maintained regardless of its flocculating ability. The membrane acts as a filter to provide clarified effluent, and as a consequence, microbial biomass retention time (SRT) becomes independent of hydraulic retention time (HRT).

Detailed Description Text (46):

Operation as a membrane bioreactor has the advantage of allowing MLSS concentrations as high as 20,000 mg/L, compared with 3,000 mg/L of conventional activated sludge bioreactors. This allows increased volumetric loading rates, reduced reactor volume, reduced hydraulic retention time, long solids retention time, and reduced solids production. Permeate (e.g., membrane effluent) contains less than 1 mg/L of TSS and extremely low turbidity. Membranes achieve coliform bacteria reductions of over 6 log orders. Permeate is well suited for further disinfection with ultraviolet (UV) radiation if required, due to its low turbidity.

Detailed Description Text (47):

Referring to FIGS. 3 and 4, the five zones of the MBR/BNR system are anaerobic zone V with 500 m.sup.3, anoxic I zone W with 1,600 m.sup.3, aerobic I zone X with 2,800 m.sup.3, anoxic II zone Y with 1,000 m.sup.3 and aerobic II zone Z with 600 m.sup.3. Mixed liquor from one zone to the next flows across baffle openings. For ease of representation the zones are presented in FIGS. 3 and 4 as separate tanks. Passage from one zone to the next is represented with arrows. Thus, 10 represents the anaerobic to anoxic I zone passage, 11 represents the anoxic I to aerobic I zone passage, 12 represents the aerobic I to anoxic II zone passage, and 13 is the anoxic II to aerobic II passage. All zones are covered and contain positive air suction connected to odour control scrubbers 37, 59, 38, 60 and 39. Overall hydraulic retention time is 3.1 days Internal sludge recirculation from anoxic I (2-4), aerobic I (2-3), and aerobic II zones (2-2) is provided by external open impeller pumps AV, AL and AL. Mixing and oxygen requirements in the aerobic I zone X are supplied by fine-bubble diffuser AI aeration. Coarse-bubble diffusers AJ installed in the lower portion of the submerged microfiltration membrane cases AA in the four separate zones of the aerobic II zone Z provide mixing and oxygen.

Detailed Description Text (48):

Additionally, coarse air bubbles scour the membranes to reduce biological build-up. Positive displacement lobe blowers AH supply air 41 for the aerobic II zone Z, while multi-stage dynamic blowers AG feed air 40 for aerobic I zone X. All zones have foam removal mechanisms. Foam is conveyed to a transfer tank, from where it is pumped to the slurry/sludge holding tank.

Detailed Description Text (49):

Twentyfour flat-plate microfiltration membrane cases located in the aerobic II zone Z provide separation of biomass from liquid. Six cases are submerged in each of four separate zones. A four-zone configuration was selected to maximize membrane filtration capacity during routine maintenance, by enabling 18 cases to remain in operation when membranes in one aerobic II zone are being maintained.

Detailed Description Text (50):

Each case has 200 vertical flat membrane cartridges, each with two 0.4-m.sup.2 flat membranes, for a total of 0.8 m.sup.2 of filtration area per cartridge, membranes have a 0.3-micron nominal pore size. Cartridges are separated from each other by a 7 mm gap. Large air bubbles released through 8-mm openings in diffusers placed below the lower section of the cases generate an upward mixed liquor cross-flow of 0.5 m/s along the gap over the membrane surface. Air requirements are 0.35 scfm per cartridge, for a total of 1,700 scfm in aerobic II zone. This airflow supplies mixing liquor flow through the membrane gaps, and oxygen requirements to maintain the zone with 1 mg/L dissolved oxygen concentration. Mixed liquor, cross-flow minimizes fouling and allows low-pressure gravity filtration through the membrane panel and thence to a permeate collection manifold.

Detailed Description Text (51):

Treated effluent flow 14 through the membranes is controlled by available gravity head above membrane cases. Typically 1.5 m of static head provide 3.5 m.sup.3 /h per case, operating at 20 g/L MLSS. This corresponds to a membrane flux of 0.5

m.sup.3 /d-m.sup.2. In-situ chemical cleaning with a backwash of 0.5 percent sodium hypochlorite solution is recommended every six months. This requires approximately 6 hours off-line per zone, while the other three are operating.

Detailed Description Text (62):

Excess phosphorus stored in poly-P bacteria during aerobic conditions can be as high as 15 percent dry mass of the mixed liquor volatile suspended solids (MLVSS) if no volatile solids digestion occurs due to excessive solids retention time. Phosphorus is removed from the system as part of the waste activated sludge 2 pumped from aerobic II zone Z. Approximately 88 percent of the phosphorus entering the MBR is removed biologically, leaving a concentration of approximately 20 mg/L in the anoxic II zone Y. This phosphorus is chemically removed, adding approximately 400 kg/d of alum 61 in the anoxic II zone Y. Aluminum reacts with dissolved phosphate to form aluminum phosphate microflocs, which are retained by the membranes and removed with waste sludge. All sludge removed from the MBR is stored and mixed in the slurry/sludge holding tanks D prior to feeding the centrifugal decanters. Permeate 14 passing the membranes contains 12 mg/L BOD, 87 mg/L COD, less than 1 mg/L TSS, 1 percent TDS, 8 mg/L TN, 1.5 mg/L TP, and 530 total coliform bacteria colonies per 100 mL.

Detailed Description Text (66):

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high volume livestock production", Hoffland, et al., U.S. Pat. No. 6,054,044: April 2000. "Method and apparatus for waste water purification", Horiguchi et al., U.S. Pat. No. 3,547,816: December 1970. "Apparatus for treating activated sludge and method of cleaning it", Ishida et al., U.S. Pat. No. 5,192,456: March 1993. "Waste treatment process", Jeris, U.S. Pat. No. 4,009,098: February 1977. "Biological fluidized bed apparatus", Josse et al., patent-pending: U.S. Ser. No. 09/839,653: November 2000. "Method and apparatus for fluidization of particulate bed materials", Khudenko, U.S. Pat. No. 6,048,459: April 2000. "Apparatus for clarification of water", Krofta U.S. Pat. No. 4,626,345: December 1986. "Organic waste processing method and uses thereof", Lasseur et al., U.S. Pat. No. 6,077,548: June 2000. "Electrochemical treatment of water contaminated with nitrogenous compounds", Lin et al., U.S. Pat. No. 6,083,377: July 2000. "Process for biologically removing phosphorus and nitrogen from wastewater by controlling carbohydrate content therein", Liu, et al., U.S. Pat. No. 5,833,856: November 1998. "Method of treating animal waste", Lloyd, U.S. Pat. No. 6,083,386: July 2000. "Sludge treatment system", Lyman et al., U.S. Pat. No. 5,279,637: January 1994. "Vertical skein of hollow fiber membranes and method of maintaining clean fiber surfaces while filtering a substrate to withdraw a permeate", Mahendran et al., RE U.S. Pat. No. 37,549: February 2002. "Enhanced denitrification process by monitoring and controlling carbonaceous nutrient addition", Maneshin et al., U.S. Pat. No. 6,106,718: August 2000. "Psychrophilic anaerobic treatment of waste in a sequencing semibatch/batch bioreactor", Masse et al., U.S. Pat. No. 5,863,434: January 1999. "Biological removal of phosphorus and nitrogen from wastewater using a stressed contact zone and luxury contact zone", Miller, U.S. Pat. No. 5,603,833: February 1997. "Methods of treating animal waste slurries", Moore, U.S. Pat. No. 6,346,240: February 2002. "Cassette membrane system and method of use for low pressure separations", Moller, U.S. Pat. No. 5,620,605: April 1997. "Stacked filter cartridge with porous filter support", Naruo et al., U.S. Pat. No. 4,871,456: October 1989. "Waste water treatment apparatus and washing method thereof", Ohtani et al., U.S. Pat. No. 5,690,830: November 1997. "Immersed membrane element and module", Pedersen et al., U.S. Pat. No. 6,325,928: December 2001. "Sludge dryer", Ratajczek, U.S. Pat. No. 5,561,917: October 1996. "Waste treatment with a combination of denitrifying propionibacterium acidipropionici and protease-producing bacillus", Rehberger, U.S. Pat. No. 6,221,650: April 2001. "Method of clarifying proteinaceous waste water containing solid impurities", Roets, U.S. Pat. No. 4,559,146: December 1985. "Method for the removal of nutrients containing carbon, nitrogen and phosphorus", Rogalla, U.S. Pat. No. 5,605,629: February 1997. "Process for sludge and/or organic waste reduction", Rozich, U.S. Pat. No. 5,141,646: August 1992. "Process for the secondary treatment of wastewater", Severeid, et al., U.S. Pat. No. 4,374,027: February 1983. "Aerobic biodegradable waste treatment system for large scale animal husbandry operations", Sheaffer, U.S. Pat. No. 6,136,185: October 2000. "Water treatment system", Sherman, U.S. Pat. No. 5,389,254: February 1995. "Filtration membrane module", Shimizu et al., U.S. Pat. No. 5,482,625: January 1996. "Waste treatment device and method employing the same", Spears, et al., U.S. Pat. No. 6,139,744: October 2000. "Process and system for treatment of pig and swine manure for environmental enhancement", Tetrault et al., U.S. Pat. No. 5,885,461: March 1999. "Sludge treatment apparatus", Wang et al., U.S. Pat. No. 5,068,031: November 1991. "Ozone disinfecting, decontaminating and deodorizing of animal manure", Wasinger, U.S. Pat. No. 6,056,885: May 2000. "Sludge treatment membrane apparatus", Wataya et al., U.S. Pat. No. 5,651,889: July 1997. "Hog waste processing apparatus and method", White, U.S. Pat. No. 6,207,057: March 2001. "Processing for treating organic wastes", Winter et al., U.S. Pat. No. 5,277,814: January 1994. "Hollow fiber membrane module", Yamanori et al., U.S. Pat. No. 5,480,553: January 1996. "Membrane treatment and membrane treatment apparatus", Yamato et al., U.S. Pat. No. 6,224,766: May 2001. "Process for high concentrated waste water treatment using membrane separation", Yoo et al., U.S. Pat. No. 6,007,719: December 1999.

Detailed Description Paragraph Table (2):

Key to Figures: Line type: -- Slurry, liquid, or solids stream - - - Control

lines Gas or air lines FIG. 1 Components (Preferred number thereof): A Bar rack (3) B Chopper pumps (3) C Macerator (3) D Slurry/sludge holding tanks (3) E Cationic polymer storage and feeding system (3) F In-line mixer (3) G Centrifugal decanter (3) H Centrate holding tanks (2) I Anionic polymer holding and feeding system (2) J Liquid alum storage and feeding system (2) BC Chemical addition diaphragm pumps, automatic control variable output (10) BD Side entry mixers for slurry and centrate storage tanks (15) BM Thermal oil heater for cake indirect dryer (3) BN Hot oil circulator pump (3) BO Indirect cake dryer (3) BP Pellet size sorter (3) BQ Paddle mixer pelletizer (3) BR Dryer water vapour condenser (2) BS Solids cake silo (3) BU Condenser cooling water circulator pump (2) BV Oil heater natural gas burner (3) FC Flow element control for chemical feed pumps LC Level switch control for submersible chopper pump NGS Natural gas supply OSD Off site solid waste disposal OC Odour control system PF Pig farm PSS Pellet Storage and shipping Streams: 1 Raw slurry to bar rack 1-1 Screened slurry to pumping pit 1-2 Chopped slurry to macerator 1-3 Macerated Slurry to storage tank 2 Waste liquor pumped from MBR aerobic 2 zone to storage tank 2-1 Liquor withdrawal line from MBR aerobic 2 zone to waste and return pumps 2-2 Liquor return from MBR aerobic 2 zone to anoxic 1 zone 2-3 Nitrified liquor return from MBR aerobic 1 zone to anoxic 1 zone 2-4 Denitrified liquor return from MBR anoxic 1 to anaerobic zone 3 Float and bottom draw-off sludge waste line from DAFT to storage tank 4 Excess solids waste line from AFBR to storage tank 5 Centrifuge feed after polymer addition and mixing. Centrifuge feed combines slurry, waste MBR mixed liquor, excess AFBR solids, and DAFT float and sludge 6 Centrate from centrifuge to centrate storage tank 6-1 Centrate after polymer and aluminum sulfate addition pumped to flash mixer and flocculator 15 Condensate from solids cake dryer indirect condenser to ammonia air stripper 17 Solids cake out of centrifuge to cake storage silo 21 Heat recuperation system. Condenser cooling water loop hot side from condenser to DAFT effluent heat exchanger 22 Heat recuperation system. Condenser cooling water loop cold side from DAFT effluent heat exchanger to condenser 29 Bar rack screenings to off site solids waste disposal 35 Ammonium sulfate removed from acid scrubber to paddle mixer pelletizer, for pellet nitrogen fortification 42 Polymer addition line from metering system to mixer before centrifuge 43 Polymer addition line from metering system to flash mixer before mechanical flocculator 44 Aluminum sulfate addition line from metering system to flash mixer before mechanical flocculator 50 Natural gas supply to thermal oil heating furnace burner. Supplies heat to indirect solids drier 51 Thermal oil loop hot feed side from oil heater to dryer 52 Thermal oil loop cold return side from dryer to oil heater 53 Wet pellet feed elevator from paddle mixer to dryer 54 Dry pellet from dryer to pellet size sorter 55 Under size dry pellet return to paddle mixer for wet cake coating 56 Finished pellet conveyor to cooling, storage and shipping 57 Water vapour extracted from wet cake, from dryer exhaust to condenser 58 Thermal oil heater combustion gas exhaust FIG. 2 Components (preferred number thereof): K Rapid mixer/flocculator (2) L Dissolved air flotation thickeners (DAFT) (2) M DAFT air saturation tank (2) N Heat exchanger (2) O Water heater (1) Q Air stripper tower (2) R Wet scrubber tower (2) S Stripping tower sodium hydroxide storage and feeding system (1) T Wet scrubber sulfuric acid storage and feeding system (1) U Sulfuric acid addition, stripped condensate pH control system (1) BA Fan make-up air addition (1) BB Fan air recirculation (1) BC chemical addition diaphragm pumps, automatic control variable output (10) BD Side entry mixers for slurry and centrate storage tanks (15) BE Variable speed rapid mixer (2) BF Variable speed flocculation mixer (2) BG Pump DAFT effluent recirculation (2) BH Compressor DAFT recycled effluent saturation (2) BI Burner natural gas auxiliary water heater (1) BJ Circulator pump auxiliary hot water system temperature controlled (1) BL Recirculation pump sulfuric acid solution ammonia scrubber (2) BT Stripped warm air release dampener valve (1) TC Temperature element control for hot water recirculation pumps pHC pH element control for caustic and acid addition diaphragm pumps NGS Natural gas supply Streams: 3 Float and bottom draw-off sludge waste line from DAFT to storage tank 6-1 Centrate after polymer and aluminum sulfate addition pumped to flash mixer and flocculator 6-2 Flocculated centrate to DAFT 7 DAFT effluent to heat exchanger 7-1 Heated DAFT effluent to AFBR 15 Condensate from solids cake dryer indirect condenser to ammonia

air stripper 15-1 Condensate at high pH after sodium hydroxide addition 16 Air-stripped condensate at high pH 16-1 Air-stripped condensate after pH neutralization with sulfuric acid to MBR 19 Hot water loop feed side from auxiliary gas fired water heater to DAFT effluent heat exchanger 20 Hot water loop return side from DAFT effluent heat exchanger to auxiliary gas-fired water heater 21 Heat recuperation system. Condenser cooling water loop hot side from condenser to DAFT effluent heat exchanger 22 Heat recuperation system. Condenser cooling water loop cold side from DAFT effluent heat exchanger to condenser 23 Effluent recirculation line from DAFT to air saturation tank 24 Air-saturated DAFT effluent line from saturation tank to DAFT center well 25 DAFT bottom sludge draw-off line to storage tank 26 DAFT float line from DAFT skimmer box to storage tank 27 Natural gas supply line feeding auxiliary hot water boiler burner 28 Hot water boiler combustion gas exhaust 30 Ammonia-laden hot air from air stripper to wet acid scrubber 31 Acid-scrubbed air return to ammonia air stripper via recirculation fan 32 Ambient air addition to air loop for temperature control. Supplied by make-up air fan 33 Ammonia recovery system exhaust air to atmosphere through dampening flow control valve 34 Sulfuric acid addition to scrubber low pH water recirculating loop 35 Ammonium sulfate removed from acid scrubber to paddle mixer pelletizer, for pellet nitrogen fortification 36 Wet scrubber low pH water recirculating loop 45 Sodium hydroxide addition line from metering system to ammonia stripper condensate feed line 46 Sulfuric acid addition line from metering system to stripped condensate line feeding MBR FIG. 3 Components (preferred number thereof): P Pre-acidification fluidized bed reactors (FBR) (2) V Biological nutrient removal (BNR) anaerobic zone (2) W BNR anoxic I zone (2) X BNR aerobic I zone (2) AB Magnesium hydroxide addition, BNR pH and alkalinity control system (2) AC BNR denitrification methanol storage and feeding system (2) AG Multi-stage dynamic blower (2) AI Fine bubble diffusers (2 systems) AL Mixed liquor return pumps from aerobic II to anoxic I zone (2) and aerobic I to anoxic I zone (2) AK Top-entry mixers anaerobic, anoxic I and anoxic II zones AV Mixed liquor return pumps from anoxic I to anaerobic zone (2) AX FBR excess solids waste pump (2) AZ FBR effluent recirculation pump (2) BC Chemical addition diaphragm pumps, automatic control variable output (10) OPRC Oxidation-reduction potential element control for mixed liquor return pumps pH element control for caustic and acid addition diaphragm pumps Streams: 2-2 Liquor return from MBR aerobic 2 zone to anoxic I zone 2-3 Nitrified liquor return from MBR aerobic I zone to anoxic I zone 2-4 Denitrified liquor return from MBR anoxic I to anaerobic zone 4 Excess solids waste line from AFBR to storage tank 7-1 Heated DAFT effluent to AFBR 8 AFBR acidified effluent to MBR 8-1 AFBR effluent recirculation line for bed fluidization 9 MBR feed combining AFBR acidified effluent and air-stripped condensate 10 Mixed liquor flow from MBR anaerobic to anoxic I zone. Line is for illustration only, in actuality all zones are in the same tank, separated with baffles 11 Mixed liquor flow from MBR anoxic I to aerobic I zone. Line for illustration only 12 Mixed liquor flow from MBR aerobic I to anoxic II zone. Line for illustration only 16-1 Air-stripped condensate after pH neutralization with sulfuric acid to MBR 36 Wet scrubber low pH water recirculating loop 37 Air duct from MBR anaerobic zone to odour control scrubbers 38 Air duct from MBR aerobic I zone to odour control scrubbers 40 Air line from multi-stage dynamic blower discharge to MBR aerobic I zone fine bubble diffuser system 47 Magnesium hydroxide alkalinity addition line from metering system to MBR nitrification aerobic I zone 48 Methanol addition line from metering system to MBR pre-denitrification anoxic I zone 49 Methanol addition line from metering system to MBR post-denitrification anoxic II zone 59 Air duct from MBR anoxic I zone to odour

Detailed Description Paragraph Table (3):

control scrubber 62 Air duct from AFBR to odour control scrubbers FIG. 4 Components (preferred number thereof): Y BNR anoxic II zone (2) Z BNR aerobic II zone (4) AA BNR submerged membrane cases with incorporated diffusers (24) AD Liquid alum storage and feeding system (2) AE Ultraviolet disinfection system (2) AF Disinfected effluent storage tank (1) AH Positive displacement lobe blower (2) AJ Coarse bubble diffusers (24) AK Top-entry mixers anaerobic, anoxic I and anoxic II zones AY On site effluent reuse pumping system (2) BC Chemical addition diaphragm

pumps automatic control variable output (10) BK Waste biomass pump aerobic II zone to slurry/sludge holding tanks (2) OC Odour control system Streams: 2 Waste liquor pumped from MBR aerobic II zone to storage tank 2-1 Liquor withdrawal line from MBR aerobic II zone to waste and return pumps 2-2 Liquor return from MBR aerobic II zone to anoxic I zone 4 Excess solids waste line from AFBR to storage tank 12 Mixed liquor flow from MBR aerobic I to anoxic II zone. Line for illustration only 13 Mixed liquor flow from MBR anoxic II to aerobic II zone. Line for illustration only 14 Permeate out of membranes flowing to UV radiation units 15 Condensate from solids cake dryer indirect condenser to ammonia air stripper 18 Disinfected permeate from UV units to effluent storage tank 18-1 Pumped effluent for on-site reuse 18-2 Effluent overflow to discharge 39 Air duct from MBR aerobic II zone to odour control scrubbers 41 Air line from lobe-type positive displacement blower discharge to MBR aerobic II zone coarse bubble diffuser system 49 Methanol addition line from metering system to MBR post-denitrification anoxic II zone 60 Air duct from MBR anoxic II zone to odour control scrubbers 61 Aluminum sulfate addition line from chemical metering system to anoxic II zone

CLAIMS:

1. A process for treating an organic slurry comprising a mixture of solids suspended in a liquid, colloidal solids and dissolved pollutants including nitrogen, phosphorus and organic matter, the process comprising: flocculating a slurry stream with anionic polymer or a coagulant, or both, to aggregate suspended and colloidal solids into a floc, to form a flocculated stream; removing flocs from the flocculated stream to form a deflocced stream; feeding the deflocced stream into a biomass concentration suspended growth system to remove biologically at least a portion of the organic and inorganic nitrogen, and remove by biological luxury uptake at least a portion of the phosphorus, wherein the system comprises: a multi-stage sequence of an anaerobic zone, an anoxic zone, and an aerobic zone, each zone separated with baffles, operating in a biomass recycle pattern from the anoxic zone to the anaerobic zone, and from the aerobic zone to the anoxic zone, with biomass wastage from the aerobic zone; and microfiltration membranes to filter liquid out of the aerobic zone to form a low-turbidity permeate.
5. The process according to claim 1 wherein the biomass concentration suspended growth system comprises: a five-stage sequence of anaerobic, anoxic 1, aerobic 1, anoxic 2, and aerobic 2 zones operating with a biomass recycle pattern from anoxic 1 to anaerobic zone, from aerobic 1 to anoxic 1 zone, and from aerobic 2 to anoxic 1 zone, with biomass wastage from aerobic 2 zone; and the microfiltration membranes filter liquid out of aerobic 2 zone to form the low-turbidity permeate.
6. The process according to claim 5, wherein at least a portion of the phosphorus that is not removed biologically is removed chemically and physically with the addition of alum, ferric chloride or polyaluminum chloride into anoxic 2 zone, to produce phosphate salts that precipitate into microflocs retained by the microfiltration membranes filtering out of aerobic 2 zone.

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L1: Entry 1 of 4

File: USPT

Apr 26, 2005

DOCUMENT-IDENTIFIER: US 6884355 B2

TITLE: Process for treating organic wastewater and apparatus for treating the organic wastewater

Detailed Description Text (136):

In the present embodiment, the sludge solid component is rinsed and the sludge dissolved component is ion-exchanged in order to remove sodium ions therefrom. However, other techniques for removing ions, such as utilizing a reverse osmosis membrane, may be applicable. Moreover, in the present embodiment, ions were removed from both the sludge solid component and the sludge dissolved component after phosphorus removal. However, depending on the effects on the anaerobic digestion tank, ions may be removed from either one of the sludge solid component after solid-liquid separation or the sludge dissolved component after phosphorus removal.

Detailed Description Text (156):

In the present embodiment, the sludge solid component is rinsed and the sludge dissolved component is ion-exchanged in order to remove sodium ions therefrom. However, other techniques for removing ions, such as utilizing a reverse osmosis membrane, may be applicable. Moreover, in the present embodiment, ions were removed from both the sludge solid component and the sludge dissolved component after phosphorus removal. However, depending on the effects on the anaerobic digestion tank, ions may be removed from either one of the sludge solid component after solid-liquid separation or the sludge dissolved component after phosphorus removal.

Detailed Description Text (176):

In the present embodiment, the sludge solid component is rinsed and the sludge dissolved component is ion-exchanged in order to remove sodium ions therefrom. However, another technique for removing ions, such as one utilizing a reverse osmosis membrane, may be applicable. Moreover, though the ion removal is conducted both for the sludge solid component after solid-liquid separation and sludge dissolved component after phosphorus removal in this embodiment, ions may be removed from either the sludge solid component after solid-liquid separation or the sludge dissolved component after phosphorus removal depending on the effects on the anaerobic digestion tank.

Detailed Description Text (417):

Further, sodium ions were removed from the above phosphorus removed water by ion exchange and, then, the resultant solution was mixed with the rinsed sludge treated with ozone and alkali in combination. Thereafter, the pH and TS concentration of the mixture were adjusted and the mixture was anaerobically digested according to the above Examples. As a result, the same effect was obtained in decrease in TS concentration and the amount of produced digester gas was increased as compared with Example in which sludge was rinsed.

Detailed Description Text (456):

According to the present invention in which at least one of influent organic wastewater, digested sludge drawn from an aerobic digestion tank and digested sludge thickened through solid-liquid separation or a mixture of these sludge is

treated with ozone and successively with alkali, the amount of eluted phosphorus is greatly increased, in addition to solubilization of sludge and transformation into methane. The eluted phosphorus is recovered as reusable phosphorus by coagulation and membrane separation and energy and phosphorus are simultaneously recovered from the sludge.

Detailed Description Text (459):

According to the present invention in which at least one of influent organic wastewater, digested sludge drawn from an aerobic digestion tank and digested sludge thickened through solid-liquid separation or a mixture of these sludge is treated with ozone in the presence of hydrogen peroxide, the amount of eluted phosphorus is greatly increased in addition to solubilization of sludge and transformation into methane. The eluted phosphorus is recovered as reusable phosphorus by coagulation and membrane separation and energy and phosphorus are simultaneously recovered from the sludge.

Detailed Description Text (461):

According to the present invention in which at least one of influent organic wastewater, digested sludge drawn from an aerobic digestion tank and digested sludge thickened through solid-liquid separation or a mixture of these sludge is treated with ozone under UV radiation, the amount of eluted phosphorus is greatly increased in addition to solubilization of sludge and transformation into methane. The eluted phosphorus is recovered as reusable phosphorus by coagulation and membrane separation and energy and phosphorus are simultaneously recovered from the sludge.

Other Reference Publication (1):

Jardin et al., "Refixation of phosphates released during Bio-P sludge handling as struvite or aluminium phosphate", Environmental Technology, 2001, pp. 1253-1262, vol. 22, Germany.

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L12: Entry 4 of 5

File: USPT

Jun 18, 2002

DOCUMENT-IDENTIFIER: US 6406629 B1

TITLE: Biological process for removing phosphorous involving a membrane filterAbstract Text (1):

A waste water treatment process for biologically removing phosphates incorporates a membrane filter. The process includes three zones, an anaerobic zone, an anoxic zone and an aerobic zone containing an anaerobic, anoxic and aerobic mixed liquor. Water to be treated flows first into the anaerobic zone. Anaerobic mixed liquor flows to the anoxic zone. Anoxic mixed liquor flows both back to the anaerobic zone and to the aerobic zone. The aerobic mixed liquor flows to the anoxic zone and also contacts the feed side of a membrane filter. The membrane filter treats the aerobic mixed liquor to produce a treated effluent lean in phosphorous, nitrogen, COD, suspended solids and organisms at a permeate side of the membrane filter and a liquid rich in rejected solids and organisms. Some or all of the material rejected by the membrane filter is removed from the process either directly or by returning the material rejected by the membrane filter to the anoxic or aerobic zones and wasting aerobic sludge. In a first optional side stream process, phosphorous is precipitated from a liquid lean in solids extracted from the anaerobic mixed liquor. In a second optional side stream process, anaerobic mixed liquor is treated to form insoluble phosphates which are removed in a hydrocyclone.

Brief Summary Text (2):

The present invention relates to waste water treatment, and more particularly to a process for removing phosphorous from waste water involving biological processes and a membrane filter.

Brief Summary Text (7):

One problem with the U.S. Pat. No. '883 process is that there can be a build-up of phosphates in the system. At the end of the process, a portion of the recycled activated sludge is wasted and is subsequently treated, typically by aerobic or anaerobic digestion processes. This results in a release of phosphorus taken up in the process. This phosphorus is then returned back to the process in the form of digester supernatant. Consequently, this reduces the efficiency of phosphorus removal in the process and results in higher levels of phosphorus in the effluent. A partial solution to this problem is to employ a side stream process called 'Phos-Pho Strip' as described in U.S. Pat. No. 3,654,147. In this process, the activated sludge, which has a high concentration of phosphorus, passes from the clarifier to a phosphorus stripper. In the stripper, phosphorus is released into the filtrate stream by either: creating anaerobic conditions; adjusting the pH; or extended aeration. The resulting phosphate-rich filtrate stream passes to a chemical precipitator. The phosphate-free effluent stream is added to the main effluent stream, the waste stream from the precipitator containing the phosphates is discarded, and the phosphate-depleted activated sludge is returned to the main process.

Brief Summary Text (9):

A second type of biological treatment is referred to as a membrane bioreactor which can be combined with chemical precipitation techniques. In a simple example, precipitating chemicals are added to an aerobic tank containing or connected to a membrane filter. As above, however, dosages of precipitating chemicals

substantially in excess of the stoichiometric amount of phosphates are required to achieve low levels of phosphates in the effluent. This results in excessive sludge generation and the presence of metallic precipitates which increase the rate of membrane fouling or force the operator to operate the system at an inefficient low sludge retention time.

Brief Summary Text (13):

Water to be treated flows first into the anaerobic zone to join the anaerobic mixed liquor. Anaerobic mixed liquor flows to the anoxic zone to join the anoxic mixed liquor. Anoxic mixed liquor flows both back to the anaerobic zone to join the anaerobic mixed liquor and to the aerobic zone to join the aerobic mixed liquor. The aerobic mixed liquor flows to the anoxic zone to join the anoxic mixed liquor and also contacts the feed side of a membrane filter. The membrane filter treats the aerobic mixed liquor to produce a treated effluent lean in phosphorous, nitrogen, BOD, suspended solids and organisms at a permeate side of the membrane filter and a liquid rich in rejected solids and organisms.

Brief Summary Text (14):

Some or all of the material rejected by the membrane filter is removed from the process. This may be done by locating the membrane filter outside of the aerobic zone and directly removing the liquid rich in rejected solids and organisms from the retentate or feed side of the membrane filter. Alternatively, the membrane filter may be located in the aerobic zone so that the material rejected by the membrane filter mixes with the aerobic mixed liquor. The material rejected by the membrane filter is then removed by removing aerobic mixed liquor. Further alternatively, the liquid rich in material rejected by the membrane filter may be recycled to the anoxic or aerobic zones. The material rejected by the membrane filter is then removed by removing aerobic mixed liquor. Combinations of the first and third methods described above may also be used.

Brief Summary Text (16):

The stream exiting the aerobic zone passes through the membrane filter. In the membrane filter, phosphorus-rich activated sludge, finely suspended colloidal phosphorus, bacteria, and other cellular debris are rejected by the membrane. A waste activated sludge containing material rejected by the membrane filter, optionally combined with aerobic mixed liquor, flows to a sludge management or processing system. A phosphorous lean effluent is produced at the permeate side of the membrane filter. The effluent is also reduced in nitrogen as a result of the anoxic and aerobic zones and the recycle between them.

Brief Summary Text (17):

The membrane filter removes colloidal phosphorus and bacteria which would normally pass through a clarifier. Although the absolute amount of colloidal solids is relatively small, the percentage of phosphorus in the colloids is surprisingly high and its removal results in unexpected low levels of phosphorus in the effluent. With membrane filters to remove biomass from the effluent stream, a fine biomass can be maintained in the anaerobic reactor. This may result in enhanced reaction rates and higher than anticipated release of phosphorus in the anaerobic reactor, with resulting higher uptake of phosphorus in the anoxic and aerobic zones. Further, since the process is not limited by the settling characteristics of the sludge, the process is able to operate at very high process solid levels, preferably with an MLSS between 3 and 30 mg/L and short net hydraulic retention times, preferably between 2 and 12 hours.

Brief Summary Text (18):

The short HRT allows increased throughput of waste water for a given reactor size. In addition, since the design avoids chemical precipitation of phosphates upstream of the membrane filters, there is reduced membrane fouling which further enhances the performance of the process. Moreover, contaminants in the sludge resulting from precipitating chemicals are reduced permitting the system to operate at a high

sludge age. At high sludge retention times, preferably between 10 and 30 days, an unexpected significant crystalline phosphorus accumulation occurs in the biomass, effectively removing phosphorus from the system. As well, there is lower net sludge generation.

Detailed Description Text (2):

A first process is shown in FIG. 1. An influent 12, which contains BOD, ammonia and phosphates, enters an anaerobic zone 14 to mix with anaerobic mixed liquor contained there. An anaerobic exit stream 16 carries anaerobic mixed liquor from the anaerobic zone 14 to mix with anoxic mixed liquor contained in an anoxic zone 18. An anoxic exit stream 20 carries anoxic mixed liquor from the anoxic zone 18 to mix with aerobic mixed liquor contained in an aerobic zone 22. An aerobic exit stream 24 carries aerobic mixed liquor from the aerobic zone 22 to the retentate or feed side a membrane filter 26 located outside of the aerobic zone 22 and preferably having microfiltration or ultrafiltration membranes. A waste activated sludge stream 32, consisting of components or material rejected by the membrane filter 26, exits from the membrane filter 26. An effluent stream 34 exits from the permeate side of the membrane filter 26 and is substantially phosphate reduced. A denitrified liquor recycle 28 carries anoxic mixed liquor from the anoxic zone 18 to mix with the anaerobic mixed liquor in the anaerobic zone 14. As well, a nitrified liquor recycle 30 carries aerobic mixed liquor from the aerobic zone 22 to mix with the anoxic mixed liquor in the anoxic zone 18.

Detailed Description Text (6):

Aerobic mixed liquor flows to the feed or retentate side of the membrane filter 26. The membrane filter 26 rejects phosphorus-rich activated sludge, finely suspended colloidal phosphorus, bacteria, inorganic particles such as grit, trash and other cellular debris. Liquid containing this rejected material forms a waste activated sludge stream 32 which may either be discarded or sent to a secondary sludge processing system, such as aerobic or anaerobic digestion. Alternatively, some of the liquid containing material rejected by the membranes can be recycled to the aerobic zone 22 through a retentate recycle stream 29 or to the anoxic zone 18 through a second retentate recycle stream 29'. When liquid containing material rejected by the membranes is recycled to the anoxic zone 18, its flow and concentration is included in any calculation of recycle from the aerobic zone 22 to the anoxic zone 18. In particular, where a second recycle stream 29' of high flux is used, it may not be necessary to provide either a retentate recycle stream 29 or a nitrified liquor recycle 30.

Detailed Description Text (7):

Referring now to FIG. 2, a second process is shown. The second process is similar to the first process but with modifications as described below. The retentate liquid containing material rejected by the membranes does not leave the process directly but are recycled back to process. This material leaves the process indirectly, combined with sludge from the process in general, as waste sludge taken from the aerobic zone 22. This waste sludge flows out of the process in a second waste activated sludge stream 31 from the aerobic zone 22 and may be periodically discarded or sent to a secondary sludge management or processing system, such as aerobic or anaerobic digestion. The liquid containing material rejected by the membranes can be recycled to the aerobic zone 22 through a retentate recycle stream 29 or to the anoxic zone 18 through a second retentate recycle stream 29'. When liquid containing material rejected by the membranes is recycled to the anoxic zone 18, its flow and concentration is included in any calculation of recycle from the aerobic zone 22 to the anoxic zone 18.

Detailed Description Text (8):

Referring now to FIG. 3, a third process is shown. The third process is similar to the first process but with modifications as described below. In the third process, a second membrane filter 33 is immersed in the aerobic zone 22. The second membrane filter 33 is driven by suction on an interior surface (permeate side) of the

membranes, the outside surface (retentate or feed side) of the membranes is in fluid communication with the aerobic mixed liquor. Thus material rejected by the second membrane filter 33 mixes with the aerobic mixed liquor without requiring a retentate recycle stream. As in the second process, material rejected by the membranes leaves the process indirectly, combined with sludge from the process in general, as waste sludge taken from the aerobic zone 22. This waste sludge flows out of the process in a second waste activated sludge stream 31 from the aerobic zone 22 and may be periodically discarded or sent to a secondary sludge management or processing system, such as aerobic or anaerobic digestion.

Detailed Description Text (11):

FIG. 4 shows a first side stream process. Although the first side stream process is shown in use with the first process of FIG. 1, it may also be used with the second and third processes of FIGS. 2 and 3. In general, a portion of the anaerobic mixed liquor is treated in a solid-liquid separation device 42. A return stream 40 rich in suspended solids, including activated sludge and organic impurities, is returned to the anoxic zone 18 and a solids lean stream (a first phosphate-rich supernatant or filtrate 44) which is rich in phosphorus is fed to a crystallizer or precipitator 50, where insoluble crystalline phosphates are removed. With this method, phosphorus is removed from the waste water treatment cycle with near stoichiometric amounts of precipitating chemicals. Phosphorous removal is enhanced because less phosphorous needs to be taken up by the Bio-P organisms in the main process. The ability to control phosphorus removal in the crystallizer or precipitator 50 through pH adjustments helps ensure that adequate phosphorus is available in the process for microbial growth to occur. Finally, a useful by-product, high purity struvite, may be recovered which can be used as a fertilizer. Alternatively, phosphates may be precipitated as a metal salt.

Detailed Description Text (12):

In greater detail, a first side stream process is shown generally at 37 and draws anaerobic mixed liquor from the anaerobic zone 36. The first side stream process 37 removes phosphorous from the main process thereby assisting to reduce the build-up of phosphorous in the system. In the anaerobic zone 14, activated sludge releases phosphorous into the liquor. As such, the anaerobic zone 14 contains liquor with the highest phosphorous concentration. A first phosphate-rich flow stream 38 is taken from the anaerobic zone 14 and sent to a separator 42. The separator 42 can use a membrane or other filter media such as a sand filter, a cloth filter, or fibre braids. The separator 42 can also be a clarifier as the inventors' experience with this process has shown the anaerobic sludge to be surprisingly settleable. A solids rich return stream 40, comprising the phosphate-depleted sludge and insoluble organics, exits from the separator 42 and recycles back to the anoxic zone 18. A first phosphate-rich supernatant or filtrate 44 exits the separator 42, is mixed with precipitating chemicals 46, such as calcium or magnesium, and a combined stream 48 is fed into a crystallizer or precipitator 50. Since the first phosphate-rich supernatant or filtrate 44 is substantially free of organic impurities, the number of undesirable side reactions with the precipitating chemicals 46 is reduced. As such, the precipitating chemicals 46 can be added in near stoichiometric amounts to precipitate out the insoluble phosphates.

Detailed Description Text (13):

A preferred method of crystallization involves using granular seed materials, preferably high density coral sands with grain size between 0.25 and 2.0 mm, to initiate and aid crystallization. Preferably, the addition of magnesium, ammonium and possibly additional phosphates allow high purity struvite ($\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$) to form and collect at the bottom of the crystallizer or precipitator 50. A bottoms flow stream 54 containing the insoluble phosphates is removed from the system and collected. A crystallizer or precipitator exit stream 52, which is both phosphate and nitrate lean may be returned to the anoxic zone 18 (52a), the aerobic zone 22 (52b) or be combined with the effluent stream 34 (52c) depending on whether it needs further treatment. For example, crystallizer or precipitator exit

stream 52 high in COD is returned to the aerobic zone to decrease its COD concentration before it is discharged from the process.

Detailed Description Text (18):

An experimental reactor was set up as shown in FIG. 3. The membrane filter consisted of four ZEEWEED.TM. ZW-10.TM. modules produced by Zenon Environmental Inc. having a total of 40 square feet of membrane surface area. A control reactor was set up as shown in FIG. 2 but (a) using a clarifier instead of the membrane filter 26, (b) recycling the clarifier bottoms to the anoxic zone 18 and (c) not using a retentate recycle stream 29 or nitrified liquor recycle 30. Both reactors had a volume of 1265 L, the volume of the clarifier not being counted as reactor volume. Sludge retention time (SRT) was kept constant at 25 days.

CLAIMS:

1. A process for treating water to remove phosphorous and nitrogen comprising the steps of:

(a) providing an anaerobic zone having an anaerobic mixed liquor having organisms which release phosphorous into the anaerobic mixed liquor and store volatile fatty acids from the anaerobic mixed liquor;

(b) providing an anoxic zone having an anoxic mixed liquor having organisms which metabolize stored volatile fatty acids, uptake phosphorous and denitrify the anoxic mixed liquor;

(c) providing an aerobic zone having an aerobic mixed liquor having organisms which metabolize stored volatile fatty acids, uptake phosphorous and nitrify the aerobic mixed liquor;

(d) flowing water to be treated into the anaerobic zone;

(e) flowing anaerobic mixed liquor to the anoxic zone;

(f) flowing anoxic mixed liquor to the anaerobic zone;

(g) flowing anoxic mixed liquor to the aerobic zone;

(h) flowing aerobic mixed liquor to the anoxic zone;

(i) contacting aerobic mixed liquor against the feed side of a membrane filter;

(j) producing a treated effluent lean in phosphorous, nitrogen, BOD OR COD, suspended solids and organisms from a permeate side of the membrane filter;

(k) removing some or all of the material rejected by the membrane filter from the process;

(l) removing anaerobic mixed liquor to a reaction zone;

(m) treating the removed anaerobic mixed liquor to form a liquid rich in insoluble phosphates;

(n) treating the liquid rich insoluble phosphates in a hydrocyclone to separate out insoluble phosphates and create a liquid lean in insoluble phosphates; and,

(o) flowing the liquid lean in insoluble phosphates to the anoxic zone, wherein the steps above are performed substantially continuously and substantially simultaneously.

2. The process of claim 1 wherein material rejected by the membrane filter is also mixed with the aerobic mixed liquor.
3. The process of claim 2 wherein the step of removing material rejected by the membrane filter from the process is accomplished by removing aerobic mixed liquor containing material rejected by the membrane filter.
4. The process of claim 1 wherein material rejected by the membrane filter is also mixed with the anoxic mixed liquor.

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L12: Entry 1 of 5

File: USPT

May 11, 2004

US-PAT-NO: 6733662

DOCUMENT-IDENTIFIER: US 6733662 B2

TITLE: Methods and apparatus for biological treatment of waste waters

DATE-ISSUED: May 11, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Pollock; David	Calgary			CA

US-CL-CURRENT: 210/97; 210/143, 210/150, 210/151, 210/188, 210/194, 210/196,
210/197, 210/202, 210/220, 210/532.1

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
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☐ 2. Document ID: US 6692642 B2

L12: Entry 2 of 5

File: USPT

Feb 17, 2004

US-PAT-NO: 6692642

DOCUMENT-IDENTIFIER: US 6692642 B2

TITLE: Organic slurry treatment process

DATE-ISSUED: February 17, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Josse; Juan Carlos	Capistrano Beach	CA		
Sutherlin; John William	New Orleans	LA		

US-CL-CURRENT: 210/605; 210/616, 210/621, 210/631, 210/903, 210/906, 71/15, 71/21

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
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☐ 3. Document ID: US 6485645 B1

L12: Entry 3 of 5

File: USPT

Nov 26, 2002

US-PAT-NO: 6485645

DOCUMENT-IDENTIFIER: US 6485645 B1

TITLE: Biological process for removing phosphorus involving a membrane filter

DATE-ISSUED: November 26, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Husain; Hidayat	Brampton			CA
Koch; Frederic	Vancouver			CA
Phagoo; Deonarine	Toronto			CA

US-CL-CURRENT: 210/605; 210/195.3, 210/196, 210/620, 210/723

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KBWC	Draw. De
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☐ 4. Document ID: US 6406629 B1

L12: Entry 4 of 5

File: USPT

Jun 18, 2002

US-PAT-NO: 6406629

DOCUMENT-IDENTIFIER: US 6406629 B1

TITLE: Biological process for removing phosphorous involving a membrane filter

DATE-ISSUED: June 18, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Husain; Hidayat	Brampton			CA
Koch; Frederic	Vancouver			CA
Phagoo; Deonarine	Toronto			CA

US-CL-CURRENT: 210/605; 210/621, 210/623, 210/624, 210/702, 210/723, 210/769,
210/801, 210/903

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KBWC	Draw. De
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☐ 5. Document ID: US 5776348 A

L12: Entry 5 of 5

File: USPT

Jul 7, 1998

US-PAT-NO: 5776348

DOCUMENT-IDENTIFIER: US 5776348 A

TITLE: Mineral precipitation system and method for inhibiting mineral precipitate formation

DATE-ISSUED: July 7, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Selengut; Jeremy D.	Brookline	MA		
Orme-Johnson; William H.	Cambridge	MA		
Dretler; Stephen P.	Whayland	MA		
Asakura; Hirotaka	Arlington	MA		

US-CL-CURRENT: 210/698; 210/702

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw De
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<u>L11</u>	truvite an magnesium and phosphorous and membrane	0	<u>L11</u>
<u>L10</u>	L6 and truvite	0	<u>L10</u>
<u>L9</u>	L7 and ammonium	36	<u>L9</u>
<u>L8</u>	L7 and struvite	0	<u>L8</u>
<u>L7</u>	L6 and magnesium	45	<u>L7</u>
<u>L6</u>	phosphorous and waste and ion exchange same membrane	84	<u>L6</u>
<u>L5</u>	struvite an ion exchnage same membrane	0	<u>L5</u>
<u>L4</u>	aeparation an precipitation same struvite and ion exchange and membrane	0	<u>L4</u>
<u>L3</u>	aeparaton an precipitation same estruvite and ion exchange and membrane	0	<u>L3</u>
ion exchange membran and seprating phosphorous andsoltion and			

L2 magnesium

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L1 membrane and ion exchange and struvite

4 L1

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